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HOW TO CONTROL THE SAN JOSE SCALE.

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THE SAN JOSE SCALE A PERMANENT FACTOR IN FRUIT GROWING.

The San Jose scale is so widely disseminated and has become so firmly established in the principal deciduous-fruit regions of this country that its extermination is now, in most cases, out of the question. In the main, therefore, the San Jose scale must be recognized as a permanent factor to be regularly dealt with as are other insect evils or the fungous diseases of plants.

Extermination is possible only where the scale is detected at the very outset on new or recently planted nursery stock or at least before any considerable chance of spread has been afforded. It is true that by the greatest care in the introduction of nursery stock the San Jose scale may, for years, perhaps, be kept out of districts now free from it, and one is warranted, therefore, in adopting every precaution to avoid introducing this scale and even to attempt extermination wherever the conditions are reasonably favorable. There is only one method of exterminating the scale, and that is by digging up and burning all infested trees. This is an heroic remedy and is advised only under the conditions of very recent introduction of nursery stock—in other words, where the scale is discovered within a few months after the purchase of the infested trees. If the scale has passed an entire breeding season in an orchard it will have spread much more widely than any inspection will indicate and very likely will have gained a footing on wild and ornamental plants other than fruit trees, from which it will reintroduce itself into neighboring orchards or into new plantings, however thorough may have been the attempts to eradicate it.

While, therefore, one is undoubtedly justified in asserting that the San Jose scale is to be a permanency, it by no means follows that the profitable growth of deciduous fruits is seriously menaced on this account. The experience in California, covering many years, and in the East now for a considerable period, has abundantly demonstrated that this scale insect can be controlled. In other words, by proper treatment, the value of which has been demonstrated by much practical experience, an orchard may be protected from serious injury and kept in a good paying condition so far as influenced by the San Jose scale.

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THE DIFFERENT MEANS OF CONTROLLING THE SAN JOSE SCALE

The methods of control which have been especially followed in the Eastern States are (1) the application of the lime-sulphur wash, (2) the soap treatment, (3) treatment with pure kerosene, (4) treatment with crude petroleum, (5) treatment with mechanical mixtures of either of the last two oils with water, (6) the application of petroleum emulsion with soap and (7) miscible oils. All of these methods have proved successful against the San Jose scale when properly carried out. The lime-sulphur wash is, however, the cheapest and safest and has become the standard remedy against the San Jose scale in commercial orchard practice. One's choice of insecticide must be governed by availability, special needs, and experience. In the main these remedies are winter treatments and may be employed at any time when the trees are in dormant, leafless condition. The weaker oil-water mixtures and the emulsions may, however, be used in the growing season. The treatments enumerated are all for trees in the orchard. Nursery stock badly enough infested to require such treatment is best destroyed. For the general disinfection of nursery stock the hydrocyanic-acid-gas treatment is the standard and only satisfactory means.

THE LIME-SULPHUR WASH.

In California, where the San Jose scale first appeared, the standard remedy against it is the lime-sulphur-salt wash, a mixture formerly used as a sheep dip in Australia and employed with little change against the San Jose scale. This wash was naturally first thought of on the discovery of the San Jose scale in eastern orchards. The earlier tests, however, conducted by this office in 1894, gave unfavorable results, and the experimentation which followed resulted in the demonstration of several distinct and valuable methods of control noted below. Later studies of the action of this wash in California led the writer in 1900 to give it a further careful trial in the East, with most successful results, demonstrating that, with favoring conditions, i. e., absence of dashing rains for a few days after the application, it would give just as good results in the Eastern States as on the Pacific coast. A year later (1901-2) very elaborate tests conducted by Doctor Forbes in Illinois showed that fairly hard rains will not always invalidate spraying with this mixture. A vast amount of experience of the most practical kind since gained, contributed to by all the eastern experiment stations and by the big commercial fruit growers of the Middle and Eastern States, has fully demonstrated the practical merit of this wash and its superiority to others in point of safety to trees and in cheapness. Its disadvantages are the difficulty of preparation and the heavy wear which it entails on apparatus—objections, however, which do not offset its notable advantages, particularly for commercial orchard work or where the number of trees to be treated is sufficient to warrant the trouble of its preparation. It is in fact the standard spray now used in commercial orchards for the San Jose scale.

Composition and preparation.—In the matter of composition of the wash, scarcely any two experimenters agree. Salt was a part of the original composition of the sheep dip and has long been retained, with the idea that it added, perhaps, to the caustic qualities, and particularly to the adhesiveness of the wash. For the latter purpose a very small amount only, 1 or 2 pounds to the

bushel of lime, need be added, following the custom in the preparation of white-wash mixtures. In practical experience, however, the salt seems to have been of very little benefit and is therefore omitted in the formula now given. The proportion of lime and sulphur is a matter of some indifference. The mixture obtained is sulphid of lime, and if an excess of lime is used it simply remains undissolved in the mixture and adds to the whitewashing character of the application. Too much lime is distinctly objectionable, however, because of the greater difficulty of spraying and harder wear on the pump and nozzles. The formula here given is substantially the one which has been hitherto recommended by this Bureau, reduced to the 45 or 50 gallon basis, or the capacity of the ordinary kerosene barrel commonly used in its preparation by the steam method.

Unslaked lime-----	pounds--	20
Flowers of sulphur-----	do-----	15
Water to make-----	gallons--	45 to 50

The flowers of sulphur, although requiring somewhat longer cooking, seems to make a better wash than ground sulphur, but the latter may be employed. Stone lime of good quality should be secured and slaked in a small quantity of water, say, one-third the full dilution. The sulphur, previously mixed up into a stiff paste, should be added at once to the slaking lime. The whole mixture should be boiled for at least one hour, either in an iron kettle over a fire out of doors or in barrels by steam. Prolonged boiling increases the percentage of the higher sulphids, but the practical end is obtained by boiling for the time indicated. In the process of making, the color changes from yellow to the clear brown of sulphid of lime, except for the excess of lime floating in it. After an hour's boiling the full quantity of cold water may be added, and the mixture should then be promptly applied in order to get its full strength before the higher sulphids are lost by cooling and crystallizing out. In transferring to the spray tank it should be passed through an iron screen or strainer, and the tank itself should be provided with an effective agitator.

Directions for use.—The wash is a winter application and can not be applied to trees in leaf. It may be applied at any time after the falling of foliage in early winter and prior to the swelling of the buds in spring. The later the application can be made the better the results, and the best period is just before the buds swell in March or April. It will probably be necessary also to make this application every year, or at least as often as the San Jose scale develops in any numbers. The wash kills the San Jose scale not only by direct caustic action, but also by leaving a limy coating on the trees, which remains in evidence until midsummer or later and kills or prevents the settling of young scale insects which may come from parents escaping the winter action.

The wear on pumps and nozzles can be kept to a minimum by carefully washing the apparatus promptly after use. The Vermorel nozzle is the best one for the wash, and additional caps may be secured to replace worn ones. The use of an air or other gas pressure pump instead of the ordinary liquid pump will save the wear of the lime on the pump. In spraying with this wash clothing is ruined, and only the oldest garments should be worn. Care should be taken also to protect the eyes to avoid unnecessary inflammation.

Range of usefulness.—This wash is distinctively the remedy for the San Jose scale and is particularly effective in applications to the smooth-bark fruit trees—such as peach, pear, and plum. In the case of the apple the terminal twigs are often covered with a fuzzy growth, more pronounced in some varieties than others, which prevents the wash from properly coating the bark. The young from scale insects which escape destruction at such points, for the reason indicated or from imperfect spraying, are driven out onto the new growth, or,

in the case of fruit spurs, onto the fruit, so that a tree on which the scale has been pretty thoroughly exterminated may nevertheless present badly spotted fruit.¹ In such cases the additional use of some one of the oil sprays may be necessary.

This wash is of nearly equal value against closely allied scale pests, such as Forbes's scale and the West Indian peach scale, and late sprayings are quite effective against the scurfy scale and the oyster-shell scale. Other insect pests which winter on the bark or about the buds are destroyed by it.

In addition to this range of usefulness against insect pests this wash has shown itself to be a valuable fungicide, notably for the peach leaf curl, sprayed trees being practically immune from this disease, so that the cost of treatment in the case of the peach is often more than made good by the fungicidal benefit alone. Later experience indicates its usefulness also as a winter application for apple scab and possibly for other plant diseases.

THE SOAP TREATMENT.

Whale-oil or fish-oil soap, preferably made with potash lye, is dissolved in water by boiling at the rate of 2 pounds of soap to the gallon of water. If applied hot and on a comparatively warm day in winter, it can be easily put on trees with an ordinary spray pump. On a very cold day, or with a cold solution, the mixture will clog the pump, and difficulty will be experienced in getting it on the trees. Trees should be thoroughly coated with this soap wash. Pear trees and apple trees may be sprayed at any time during the winter. Peach trees and plum trees are best sprayed in the spring, shortly before the buds swell. If sprayed in midwinter or earlier, the soap solution seems to prevent the development of the fruit buds, and a loss of fruit for one year is apt to be experienced, the trees leafing out and growing, however, perhaps more vigorously on this account. The soap treatment is perfectly safe for all kinds of trees and is very effective against the scale. With large trees or badly infested trees, preliminary to treatment it is desirable, with this as well as other applications, to prune them back very rigorously. This results in an economy of spray and makes much more thorough and effective work possible. The soap may be secured in large quantities at from 3½ cents to 4 cents a pound, making the mixture cost, as applied to the trees, from 7 cents to 8 cents a gallon. The success of the soap treatment is largely influenced by the character of the soap used. Many brands are on the market, mostly made with soda lye. A potash soap should be insisted on, and one that does not contain more than 30 per cent of water. The soda soap washes are apt to be gelatinous when cold and difficult or impossible to spray except when kept at a very high temperature.

OIL WASHES AND EMULSIONS.

The scale washes enumerated under this heading, in which petroleum is the principal ingredient, are often more available for limited work than the lime-sulphur wash. The precautions noted under each should be carefully attended to, as otherwise serious damage may result.

Kerosene treatment.—The kerosene treatment consists in spraying the trees with ordinary illuminating oil (coal oil or kerosene). The application is made at any time during the winter, preferably in the latter part, and by means of a spray pump making a fine mist spray. The application should be made with the greatest care, merely enough spray being put on the plant to moisten the trunk and branches without causing the oil to flow down the trunk and collect

¹ See Bul. 46, Bur. Ent., U. S. Dept. Agr., p. 54.

about the base. With the use of this substance it must be constantly borne in mind that careless or excessive application of the oil will be very apt to kill the treated plant. The application should be made on a bright, dry day, so that the oil will evaporate as quickly as possible. On a moist, cloudy day the evaporation is slow, and injury to the plant is more apt to result. If the kerosene treatment be adopted, therefore, it must be with a full appreciation of the fact that the death of the tree may follow. This oil has been used, however, a great many times and very extensively without consequent injury of any kind. On the other hand, its careless use has frequently killed valuable trees. Its advantages are its effectiveness, its availability, and its cheapness, kerosene spreading very rapidly and much less of it being required to wet the tree than of a soap and water spray. Pure kerosene is more apt to be injurious to peach and plum than to pear and apple trees, and the treatment of the former, as with the soap wash, should be deferred until spring, just before the buds swell. With young trees especially it is well to mound up about the trunk a few inches of earth to catch the overflow of oil, removing the oil-soaked earth immediately after treatment.

The crude-petroleum treatment.—Crude petroleum is used in exactly the same way as is the common illuminating oil referred to above. Its advantage over kerosene is that, as it contains a very large percentage of the heavy oils, it does not penetrate the bark so readily, and, on the other hand, only the light oils evaporate, leaving a coating of the heavy oils on the bark, which remains in evidence for months and prevents any young scale, which may come from the chance individuals that were not reached by the spray, from getting a foothold. Crude petroleum comes in a great many different forms, depending upon the locality, the grade successfully experimented with in the work of this Bureau showing 43° Baumé. Crude oil showing a lower Baumé than 43° is unsafe, and more than 45° is unnecessarily high. The lower specific gravity indicated (43°) is substantially that of the refined product, the removal of the lighter oils in refining practically offsetting the removal of the paraffin and vaseline. The same cautions and warnings apply to the crude as to the refined oil.

The oil-water treatment.—Various pump manufacturers have placed on the market spraying machines which mechanically mix kerosene or crude petroleum with water in the act of spraying. The attempt is to regulate the proportion of kerosene so that any desired percentage of oil may be thrown out with the water and be broken up by the nozzle into a sort of emulsion. Some of these machines, when everything is in good working order, give fairly satisfactory results, but absolute reliability is far from assured. The best outlook for good apparatus of this sort seems to be in carrying the oil and water in separate lines of hose to the nozzle, uniting them in the latter, and in maintaining an absolute equality of pressure on both the oil and the water tanks by employing compressed air as the motive force, kept up by an air pump, the air chamber communicating with both of the liquid receptacles. One or more manufacturers are now working on apparatus of this general description. A 10-per-cent-strength kerosene may be used for a summer spray on trees where the San Jose scale is multiplying rapidly and where it is not desirable to let it go unchecked until the time for the winter treatment. The winter treatment with the water-kerosene sprays may be made at a strength of 20 per cent of the oil. Applications of the oil-water spray should be attended with the same precautions as with the pure oil, and there is even somewhat greater risk, owing to the natural tendency one has to apply the dilute mixture much more freely than the pure oil. The application should be merely enough to wet the bark and should not, to any extent, at least, run down the trunk. The collection of water and oil about the trunk is just as dangerous to the tree as is the pure oil.

In the use of the oil sprays noted above, one who has had no experience with them is advised to make some careful preliminary tests to fully master the process, preferably waiting two or three weeks to determine the results before entering on a general treatment of the orchard. It is well, also, with the oil-water mixtures to test the pump from time to time, spraying into a glass jar or bottle to determine by actual measurement whether the correct percentages of oil and water are being maintained.

Petroleum-soap emulsions.—The kerosene-soap emulsion, following chiefly the Riley-Hubbard formula, has been one of the standard means against scale insects for twenty years. The distillate emulsion generally employed in California for spraying citrus trees, on which the lime-sulphur wash can not be used, is substantially the same thing, except that it is made with the California distillate or petroleum oil. Crude petroleum of any kind, as well as the refined product, may also be used in making this emulsion. The use of the soap emulsion against the San Jose scale in the East has not been very general on account of the greater facility with which the pure oil or oil-water mixtures can be applied. The difficulty of obtaining uniform results with the latter has led to a return to the use of emulsions to some extent, and there can be no doubt about their superior merit when it is desired to dilute the pure oils. Emulsions may be applied at any strength with absolute confidence that there will be no variation. Where the emulsion can be prepared wholesale by steam power, its employment is attended with no difficulties. In California it is prepared by oil companies and sold at very slightly more than the cost of the oil and soap ingredients. It is made after the following formula:

Petroleum -----	gallons..	2
Whale-oil soap (or 1 quart soft soap) -----	pound..	$\frac{1}{2}$
Water (soft)-----	gallon..	1

The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the oil. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, the emulsion will keep indefinitely and should be diluted only as wanted for use.

In limestone regions, or where the water is very hard, some of the soap will combine with the lime or magnesia in the water, and more or less of the oil will be freed, especially when the emulsion is diluted. Before use, such water should be broken with lye, or rain water should be employed.

For winter sprays dilute the emulsion with either 3, 4, or 5 parts of water, giving a percentage of oil approximately 17, 13, and 11 per cent. The strength in oil of this application on trees as compared with the oil-water sprays is the equivalent of 25, 20, and 15 per cent oil, because relatively more of the heavier oil-soap emulsion is held by the bark. The two stronger mixtures may be used on apple and pear and the weaker one on peach and plum.

For summer applications dilute with 7, 10, or 15 parts of water, giving approximately 8, 6, and 4 per cent of oil. The weaker strengths may be used on trees with tender foliage, such as that of peach, and the greater strength for strong foliage plants, like the apple and pear.

Miscible oils.—It will be noted that the difficulty to be overcome in the use of oils is to effect their dilution to render them harmless to the plant. The dilution is effected with great accuracy by the kerosene-soap emulsion, and less accurately by the mechanical emulsions of oil and water. There have appeared

during the last few years various so-called miscible oils, which readily and permanently mix with water, and can be applied with the same readiness and accuracy of strength as the emulsions of kerosene and soap. These oils have for their principal ingredients some form of petroleum rendered soluble by the addition of a percentage of vegetable oils and cut or saponified with an alkali, and they are, in fact, a sort of liquid petroleum soap. They are sold under various trade names. They have the disadvantage of costing a good deal more than the standard emulsions or the lime-sulphur wash, but have the great advantage of being always ready for immediate use without troublesome preparation. They can not be diluted for winter applications against scale insects with more than 10 or 15 parts of water to give good results, and there is some danger of injury to the trees if they are carelessly or excessively applied. They have, however, a very useful place, and especially as furnishing a good insecticide where only a few trees are to be treated and the owner would probably not go to the trouble of preparing an emulsion or the lime-sulphur wash. They have been so far principally used against the San Jose scale as dormant tree washes.

FUMIGATION OF NURSERY STOCK.

All nursery stock which is under the least suspicion of contamination with the San Jose scale should be fumigated; and it is perhaps worth while to fumigate in any case to give the utmost assurance of safety to the purchaser. The hydrocyanic-acid-gas fumigation is the one to use. This gas is generated by combining potassium cyanid, sulphuric acid, and water. The proportions of the chemicals are as follows: Refined potassium cyanid (98 per cent), 1 ounce; commercial sulphuric acid, 1 ounce; water, 3 fluid ounces—to every 100 cubic feet of space in the fumigating room or house. The latter should be as nearly air-tight as possible and provided with means of ventilation above and at the side, operated from without, so that at the end of the treatment the poisonous gases may be allowed to escape without the necessity of anyone entering the chamber. The generator of the gas may be any glazed earthenware vessel of 1 or 2 gallons capacity, and should be placed on the floor of the fumigating room. The water should first be poured into it, then the acid, and lastly the cyanid should be added, preferably in lumps the size of a walnut. Promptly after adding the cyanid the room should be vacated and the door made fast. The treatment should continue forty minutes. *It must be borne in mind that the gas is extremely poisonous and must under no circumstances be inhaled.* The gas treatment is effective also against the scale on growing trees in the orchard; but the difficulty and expense of the treatment, except for nursery stock, make it prohibitive in the case of deciduous fruits.

Approved:

JAMES WILSON,

Secretary of Agriculture.

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